vents the extension of transportation lines in that region; the dryness of the Gobi Plateau has prevented China from expanding westward. What a nation shall raise depends upon the climate of the region in which that nation happens to be situated, and what is produced influences the laws, habits, and customs of the whole people. North America owes more to its variety of climate than to its variety of soil. A temperate climate, with its recurring periods of heat and cold, is responsible for our being the busy, bustling nation that we are.

RELATIONS BETWEEN VELOCITIES OF PROGRESSION OF LOWS AND THE AREAS OF RISING AND FALLING PRESSURE ACCOMPANYING THEM.

By STANISLAV HANZLIK, Ph. D. (Prague). Dated Washington, D. C., February 24, 1906.

Before entering on this subject, which is a further contribution to the answer of question No. 2, as stated in the introduction to my paper in the MONTHLY WEATHER REVIEW, August, 1904, Vol. XXXII, pp. 358–363, I wish to quote some lines from Professor Ekholm's paper in the Meteorologische Zeitschrift for August, 1904, to which I partially owe the impulse that started this study. Ekholm in his paper entitled "Weather Charts of Pressure Oscillations (Wetterkarten der Luftdruckschwankungen)" presents a suggestion how to better the present status of weather forecasting in Europe. In his introduction he quotes a proposition once made by the English meteorologist, Clement Ley, that thousands of weather charts should be systematically arranged in the form of a weather dictionary and made accessible to the public by publication. The forecast would then be given by predicting the appearance of a chart having a specific number in this dictionary. Ekholm says, "I do not know at present any better method than this one, and have for more than ten years been occupied with the construction of a weather dictionary".

In the next paragraph Ekholm turns to weather forecasting, to the methods of to-day and to the faults of the methods. After that he takes up the main subject of his paper, namely, the charts of pressure changes, and tries to show from a mathematical point of view the importance of such charts for a deeper understanding of the weather and improvement in weather forecasting. The interval between two successive charts should be so short that we may clearly see how the conditions shown by one chart developed from those of the preceding. In this way we learn the nature of the interpolation of the weather function and a proper understanding of this allows us to take the next step, i. e., the extrapolation from the last chart, or in other words the forecasting of the weather. This latter can be done only by means of empirical methods, on account of the incompleteness of our observations and the imperfections of theoretical hydrodynamics.

Ekholm explains the construction of pressure change charts as follows: Let us enter on our synoptic charts, for each station, the change of pressure from one reading to the next, and draw the lines of equal change; then we find, in general, closed curves of the same form as the cyclones and anticyclones. In one area the pressure has risen; he calls this the area of rise (Steigungsgebiet), with a place of greatest rise (Steigungscentrum), and similarly elsewhere an area of fall with a center of greatest fall.

According to Ekholm probably the first[1] who made use of these pressure change charts for weather forecasting in Europe was Brounow, who in 1878 published a paper entitled: *The pressure change charts and the method of determining the direction*

of motion of a barometric minimum in the immediate future[2], wherein he shows that in certain cases the track of the low for the next day can be determined by means of the areas of fall and rise, but though he excludes all complicated cases the accordance with observations is not quite satisfactory. This subject was later investigated by Sresnewsky in his paper: *Large oscillations of the air pressure in the year 1887.*[3]

The results of the investigation on the relation of areas of falling and rising pressure to the lows are given by Sresnewsky in the following sentences:

(1) The center of the cyclone is always to the left of the point of most rapid fall of pressure. (2) This is explained as due to the great eccentricity of the outer isobars of the cyclone and also due to the difference of barometric gradients on both sides of cyclones. (3) The area of most rapid decrease in the southeast quadrant of the cyclone coincides with the area of strongest storms, and moves nearly parallel to the center of the cyclone. (4) There are cases when the area of fall moves apparently independently of the cyclone while the latter remains nearly stationary in the extreme north of Europe.

These are the most important points in Sresnewsky's investigation that concern the relations of cyclones to the areas of fall and rise. These atmospheric waves are, in Ekholm's opinion, very important phenomena. When there are strong storms in Swedish waters the areas of fall and rise follow similar tracks parallel to each other, while the cyclone keeps somewhat to the left of the track of the area of fall. When the cyclone reaches the land the intensity of the storm diminishes, the velocity of motion of the storm decreases, and the areas of fall and rise, with some delay, move in a southern or southwestern direction as if there were no apparent connection between them and the cyclonic area. The continued study of these areas of change in their relation to the cyclones led Ekholm to believe that for the weather and wind these are of greater importance than the cyclones themselves. "It seems to me highly probable", says Ekholm, "that these oscillations are caused by the cyclones and anticyclones of higher levels, which sometimes, but not always, cause a corresponding cyclone or anticyclone on the surface of the earth". Worthy of mention is the cyclonic character of the area of fall, namely the overcast sky and the occurrence of rain. Ekholm closes his paper with some remarks on the charts of change for other meteorological elements.

*   *   *   *   *   *   *

While in Harvard University preparing my paper published in the MONTHLY WEATHER REVIEW (August 1904, page 358,) I tried to draw the pressure change charts for the study of different velocities of lows. I temporarily abandoned this work on account of the great labor, but when I obtained access to the pressure change charts in the central office in Washington I took the study up again with much greater interest, after I had read and thoroughly studied the above-mentioned papers of Ekholm and Sresnewsky.

For the investigation of the relations between the lows and the areas of rise and fall, I used a scheme which may be explained as follows:

I considered lows for three successive weather maps at intervals of twelve hours, for instance, 8 a. m., 8 p. m., and the next following 8 a. m.; or 8 p. m. and the next following 8 a. m. and 8 p. m. The length of the track between the three readings was measured and the lows were grouped in two classes: those with "increasing" and those with "decreasing" velocity—according to whether the length of the track in the second half, between the second and third observation,

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[1] The charts of changes of temperature and pressure for each eight hours and twenty-four hours began to be constructed and used by the Weather Bureau (Signal Service) in 1872; the corresponding charts for twelve and twenty-four hours still continue. Many studies of these charts were made in the United States before or Brounow's paper of 1878.—EDITOR.

[2] P. Brounow. "Von den Aenderungskarten und die Methode, etc." Anhang zu dem Bulletin für das Jahr 1879. Central Physical Observatory, St. Petersburg, Dec. 18, 1878. (Lithograph, with 5 charts.)

[3] Ueber starke Schwankungen des Luftdruckes im Jahre 1887. Bull. Soc. Imp. Nat. Moscou, 1895, No. 3.

was longer or shorter by at least 200 miles than in the first half. For the determination of distances between the lows and the accompanying areas of falling and rising pressure a system of rectangular coordinates was used, but somewhat differently from the manner in which it was used by Sresnewsky.

A rigid rectangular system was so applied to a weather map that the coordinates of the center of the low for the second reading were $X_2=0$, $Y_2=0$; the track between the second and the third reading was made coincident with the positive axis of X, so that the coordinates of the low at the third reading were $X_3 > < 0$, $Y_3=0$. The coordinates of the low at the first reading were $-X$, $+Y$, or $-X$, $-Y$ according to whether the track of the low was concave or convex toward the positive axis of Y. This may be understood from fig. 1. The positions of the areas of rise and fall[4] were expressed in the same system of coordinates. So for three readings of the low I had six additional readings of the areas of rise and fall. In order to express myself more briefly, I will use the following abbreviations: L_1 denotes the position of the *low* at the first reading, similarly L_2 and L_3; F_1 is the position of the area of *fall* which is associated with L_1, and similarly F_2 and F_3. A similar meaning attaches to R_1, R_2, and R_3 as denoting the positions of the areas of *rise* for three successive readings. Having thus taken from the manuscript pressure charts the coordinates of L_1, L_2, L_3; F_1, F_2, F_3; R_1, R_2, R_3; I could by means of these coordinates determine the following distances:

(1) F_1-F_2, F_2-F_3, and R_1-R_2, R_2-R_3; that is, the lengths of the tracks of the areas of fall and rise, respectively.

(2) R_1-F_1, R_2-F_2, R_3-F_3; that is, the respective distances of the areas of fall and rise as both advance with the low.

(3) R_1-L_1, R_2-L_2, R_3-L_3; that is, the distance of the area of rise from the low and also the change of this distance as the velocity of the low increases or decreases.

(4) F_1-L_1, F_2-L_2, and F_3-L_3; that is, the distance between the low and its accompanying area of fall and the changes of this distance.

For instance let us take one concrete case of a low with decreasing velocity.

Area of low pressure.			Area of falling pressure.			Area of rising pressure.		
Location.			Location.			Location.		
L_1	L_2	L_3	F_1	F_2	F_3	R_1	R_2	R_3
X Y	X Y	X Y	X Y	X Y	X Y	X Y	X Y	X Y
−140 +380	0 0	+220 0	−270 +320	−60 −40	+310 −80	−410 +860	−330 +630	−210 +380

From these the following values can be computed:[5]

(1) F_1-$F_2=416$, F_2-$F_3=372$; the difference between these two is negative (i. e. the second minus the first) which means that the velocity of the area of fall has decreased. R_1-$R_2 = 242$, R_2-$R_3 = 277$; the difference between these is positive; hence, the velocity of the area of rise has increased.

(2) The distances R_1-F_1, R_2-F_2, R_3-F_3, are 559, 722, and 696, respectively. If we take into consideration only the last two numerical values, we see that the distance between the centers of rise and fall has shortened, namely, from 722 to 696.

(3) The distances F_1-L_1, F_2-L_2, F_3-L_3, are 144, 72, and 121, respectively. If, again, we consider the last two values, we

[4] In case of the coordinates of the areas of falling or rising pressure I mean the coordinates of the places of greatest change of pressure within the last twelve hours.

[5] We subtract the second values of X and Y from the first values, respectively, and compute the square root of the sum of the squares of their differences. To find F_1-F_2: X_1-$X_2 = -210$; Y_1-$Y_2 = 360$; then

$$F_1\text{-}F_2 = \sqrt{(X_1\text{-}X_2)^2 + (Y_1\text{-}Y_2)^2} = \sqrt{(-210)^2 + (+360)^2} = 416.$$

see that the distance between the centers of the low and the falling area has lengthened, namely, from 72 to 121.

(4) Corresponding values for R_1-L_1, etc., or the successive distances of the centers of the area of rise and the low are 552, 713, 575. The last two values show that the distance between low and area of rise has decreased.
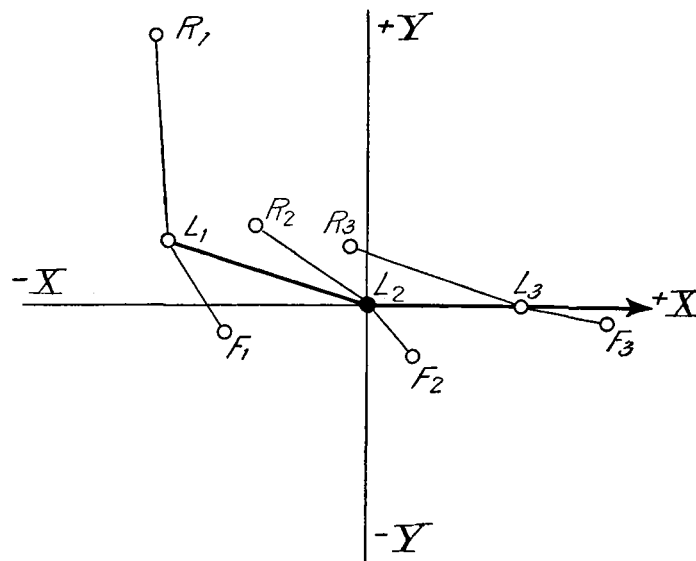

FIG. 1.—Coordinates of the centers of areas.

If we briefly summarize the results for the low in question, we have the following statements: First, the movement of the low decreased from 405 miles in the first twelve hours to 220 miles in the next twelve hours; second, the velocity of the area of fall preceding it decreased; third, that of area of rise increased; fourth, the distance between the areas of fall and rise decreased; fifth, the distance between the low and its forerunning area of fall increased; sixth, the distance between the low and its following area of rise decreased. If we denote the increase simply as $(+)$ and the decrease as $(-)$, we can briefly express the above by signs as follows:

1 Low (−)	2 F (−)	3 R (+)	4 RF (−)	5 FL (+)	6 RL (−)

TABLE 1.— *Lows moving with decreasing velocity.*

(N., NNE., NE., ENE., E., ESE., denotes the azimuth of the track of the cyclone between the second and third readings.)

Trend and length of track.	F.	R.	RF.	FL.	RL.	Trend and length of track.	F.	R.	RF.	FL.	RL.
N., NNE.						NE., ENE.					
51	+	−	+	+	+	83	+	−	−	+	−
51	+	+	−	+	−	64	+	−	+	+	+
42	−	+	−	+	−	64	−	+	+	+	−
42	+	−	−	+	−	64	+	−	−	+	−
82	+	?	−	+	−	64	−	?	+	−	−
53	−	−	−	+	−	74	−	+	−	−	−
53	−	−	−	+	−	75	−	+	−	−	−
73	+	+	−	+	−	75	−	−	+	+	+
64	+	+	−	+	−	85	−	?	+	−	+
64	+	+	−	−	+	95	−	−	+	+	+
86	−	−	−	−	−	97	+	−	+	+	+
75	+	?	+	−	+	E.					
NE., ENE.						41	−	?	?	+	?
31	+	−	−	+	−	51	{+? {+5	+	{−	+?	−
31	{+ {+	−	+	+?	−	42	−	+	−	+	−
31	+	+	+	+5	−	42	−	+	−	+	−
41	−	+	−	+	−	53	+	+	−	+	−
42	−	{+? {+5	−	+	{−? {−5	63	−	−	+	+	−
						73	+	−	+	+	−
42	−	−	+	+	+	84	+	+	−	+	−
42	−	−	+	−	−	75	+	+	−	+	−
52	−	−	+	−	−	ESE.					
62	{−? {+5	−	{+ {+?	−? {+5	−	52	−	−	−	−	−
53	−	+	+	−	−	53	+	+	−	+	−
53	{−? {+5	−	−	+	−	64	−	−	+	−	+
63	−	−	−	−	−	64	−	−	−	+	−
						64	−	+	−	−	−
						74	+	+	−	−	−

TABLE 2.—*Lows moving with increasing velocity.*

(N., NNE., NE., ENE., E., ESE., denotes the azimuth of the track of the cyclone between the second and third readings.)

Trend and length of track.	F.	R.	RF.	FL.	RL.	Trend and length of track.	F.	R.	RF.	FL.	RL.
N., NNE.						**NE., ENE.**					
13	{+/+}	+	{+/+}	{+/+}	—	36	+	—	—	—	—
13	—	—	—	—	—	37	—	{—/—}	{+/+}	—	{+/+}
13	+	+	—	—	—	37	{+/—}	?	+	+	+
18	—	?	—	—	+	37	—	?	+	—	{+/?}
24	+	?	—	—	—	38	?	?	?	—	?
25	+	—	+	0	+	46	{+/+}	—	{+/+}	{+/+}	+
25	?	—	+	—	+	46	+	—	+	0	+
35	{+/+}	+	{+/+}	{—/+}	+	46	+	—	+	+	+
36	+	—	—	+	+	46	—	—	—	—	—
46	+	—	+	+	+	46	+	+	?	—	?
48	—	+	—	—	+	46	+	?	?	—	?
NE., ENE.						46	+	+	—	+	+
13	+	+	?	?	?	46	+	—	+	+	+
13	+	?	?	0	?	46	—	+	+	—	—
13	—	{+/—}	{—/+}	—	+	46	—	+	+	—	—
13	{+/—}	—	—	{—/+}	—	47	—	+	—	—	—
14	?	—	?	{+/+}	+	47	—	{—/—}	+	—	+
15	—	+	—	+		47	+	—	+	—	+
15	+	{—/—}	{+/+}	...	{+/+}	49	{+/+}	+	{0/—}	—	—
15	—	—	—	—	—	57	{+/+}	+	—	—	—
18	+	+	+	—	+	57	—	—	+	+	+
18	—	—	+	—	+	58	—	—	—	—	+
24	+	—	—	—	+	58	+	+	+	0	+
24	—	+	—	—	—	68	—	—	—	—	+
24	—	+	+	+	—	**E.**					
24	+	—	+	+	+	13	+	—	+	+	—
24	+	+	+	+	+	16	+	—	+	+	+
25	+	—	—	+	+	17	—	—	+	—	+
25	+	+	—	—	+	18	—	—	—	—	+
25	—	+	+	—	+	24	+	—	+	—	+
25	+	+	?	—	+	24	+	+	+	+	—
25	?	—	?	?	+	25	+	—	+	—	+
25	+	?	+	—	+	26	—	+	—	—	+
25	+	—	—	—	+	26	—	+	+	—	+
26	{+/+}	—	{+/+}	{—/+}	+	26	—	+	—	—	+
26	—	+	—	—	+	27	+	+	—	—	+
26	+	+	+	—	+	35	+	+	—	+	—
27	+	+	+	—	+	35	+	+	?	+	+
27	+	—	+	—	+	35	+	?	?	0	?
27	+	—	+	—	+	35	?	—	?	?	
27	+	?	—	—	0	35	+	+	—	+	+
27	—	?	+	—	{+/+}	35	?	—	?	?	—
27	—	+	—	—	+	36	+	{—/—}	{+/?}	—	{+/?}
35	—	+	+	—	+	36	—	+	{+/+}	—	{+/+}
35	—	+	+	—	+	37	+	—	+	—	+
35	—	+	—	—	+	46	+	+	+	—	+
35	+	—	—	+	—	48	+	—	+	—	+
35	—	+	—	—	+	48	+	+	+	+	+
35	+	—	+	+	+	57	—	+	—	—	+
35	—	—	+	—	+	57	+	+	—	—	+
35	{+/+}	—	+	—	+	69	—	—	—	—	+
35	—	+	+	—	+	**ESE.**					
35	+	—	+	0	+	15	—	—	—	—	+
36	+	+	+	+	+	24	+	—	—	—	+
36	—	{—/+}	+	—	+	24	+	—	—	—	+
36	+	—	+	0	+	25	—	—	+	—	+
36	—	—	—	—	+	35	+	—	+	—	+
36	—	—	—	—	+	35	+	+	+	+	+
36	{+/—}	?	{—/+}	{—/+}	+	35	+	+	+	+	+
36	—	+	+	—	+	36	{—/+}	+	+	—	+
						46	—	+	—	+	+
						57	+	+	—	+	+

This process, thus exemplified, of computing the numerical values of the coordinates and distances was carried out for about 170 cyclones, which as above mentioned, were classified as lows with increasing and decreasing velocities, respectively. There were about 120 lows with increasing velocities and 50 with decreasing for the period 1893–1902.

I do not give here, *in extenso*, the tables for these 170 cyclones, with the distances enumerated under (1), (2), (3), and (4), as it would take too much space, but in Tables 1 and 2 give briefly the resulting (+) and (—) signs as just illustrated for the two groups of increasing and decreasing lows.

The first column gives the length of the track in the first and second twelve hours in brief form; for instance, (51) means that the center of the low moved with a velocity of between 500 and 600 miles in the first twelve hours, but decreased to a velocity of from 100 to 200 miles in the second twelve hours. It is plain that besides the signs (+) and (—) we may get results represented by the signs (?) and (0), the first case meaning

that the distance could not be measured, the second, that there was no change. There are cases where the areas of fall and rise split, or another area is formed, so that two distances come under consideration, and therefore we have double signs

of $\left(\begin{smallmatrix}+\\+\end{smallmatrix}\right)$, $\left(\begin{smallmatrix}-\\-\end{smallmatrix}\right)$, $\left(\begin{smallmatrix}+\\-\end{smallmatrix}\right)$, $\left(\begin{smallmatrix}-\\+\end{smallmatrix}\right)$, etc. Of these six probable cases

only the cases of (+), (—), $\left(\begin{smallmatrix}+\\+\end{smallmatrix}\right)$, and $\left(\begin{smallmatrix}-\\-\end{smallmatrix}\right)$ were taken into consideration, the third and fourth being counted as one (+) and as one (—), respectively.

For each of the five columns in Tables 1 and 2 the positive and negative cases were summed and the results are as follows:

Lows with velocities decreasing.	F.	R.	RF.	FL.	RL.
Number of + cases	25	20	16	34	10
Number of — cases	23	23	33	15	39
Ratio	(+)1.09	(—)1.15	(—)2.06	(+)2.26	(—)3.90
	(—)1.00	(+)1.00	(+)1.00	(—)1.00	(+)1.00

Lows with velocities increasing	F.	R.	RF.	FL.	RL.
Number of + cases	61	50	60	26	84
Number of — cases	48	57	49	79	31
Ratio	(+)1.27	(—)1.14	(+)1.22	(—)3.04	(+)2.71
	(—)1.00	(+)1.00	(—)1.00	(+)1.00	(—)1.00

The ratios were so formed for the numbers of negative and positive cases that the smaller number of cases was taken as unity. Comparing these ratios for the cases of the lows of accelerating velocity and of those of decreasing velocity we see that the character of the ratios for F and R is the same, but that for RF, FL, and RL it is opposite. What does this mean?

(1) The areas of *fall*, whether they precede lows with *increasing* or *decreasing* velocity, seem to have in *more* cases a tendency to move with *accelerating* velocity than with decreasing velocity; the opposite seems to be the case for the areas of *rise*. That would suggest (if I can put any reliance on the slight excess of the percentage) that there seems to be no causal relation between the velocities of the lows and those of the accompanying areas of rise and fall.

(2) As to the RF, we see that the change of the distance corresponds with the velocity of the low in the majority of cases.
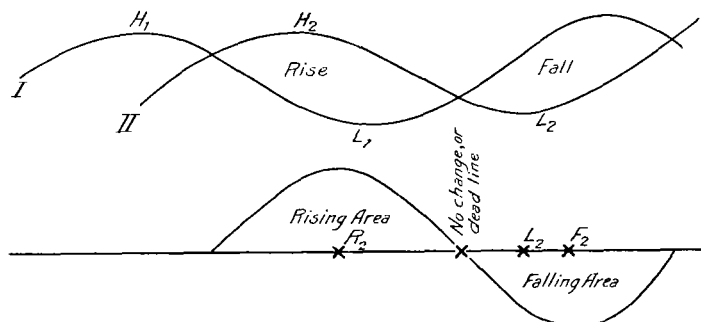

FIG. 2.— Curves of pressure and of changes of pressure.

(3) The character of the changes of RL and FL is opposite; if the low increases in velocity then, in the majority of cases, the distance FL decreases and the distance RL increases, the opposite being true for the lows of decreasing velocity. This result is plain and could be derived *a priori* from the study of the pressure change charts by any one familiar with their construction. I will explain it as follows: imagine a pressure chart; draw a line connecting the low and its following high,

and draw in rectangular coordinates pressure, Y, as a function of the distance (between the low and high), X, then we get in general a sinusoidal curve as in fig. 2. Suppose, now, that the whole system of isobars should move, for instance, eastward for some hundreds of miles without changing the form or the mutual distances of the isobars. Draw this sinusoidal curve once more in the diagram. Plotting the differences of the ordinates we get a wave representing the area of fall and rise.

This figure shows in general why the distance RL is about two, three, or even four times as long as the distance LF; it explains also why LF is shorter and RL longer for the lows which moved a greater distance in twelve hours, that is, for those that moved with greater velocity as compared with those that moved with smaller velocity. The distance RF, i. e., the distance of the area of fall from the area of rise, is, according to fig. 2, equal to the distance HL, that is, the distance of the high from the low. The deduction (2) could, therefore, not have been inferred *a priori* as it implies a change of the form of the wave; namely, for lows with increasing velocities the lengthening and steepening of the wave between H_2 and L_2, that is in the rear of the low. This means, in other words, the steepening of the gradients in the rear of the low, and naturally also an increase of the velocity of the low. The opposite is true for the lows with decreasing velocity, namely, a shortening of wave length. Let us imagine, for instance, an atmosphere homogeneous and sharply defined on its outer boundary, so we can observe its surface. The changes of the pressure due to the progress of the lows and highs would present themselves as waves progressing eastward; the wave would lengthen with increase of the velocity of the low, and would shorten with the decrease of the velocity of the low.

Most curious to me seems the fact about the velocities of F and R mentioned under (1). It seems to indicate, as I already mentioned, that there is no relation between the *velocities* of the lows, the preceding areas of fall, and the following areas of rise. The tendency of the area of rise seems to be to move with *decreasing* velocity while moving after the low; *however the velocity of the low may change*, the character of the change of velocity of R seems to be unaffected by that of the low. I am inclined to believe that in the areas of fall and rise we have found something independent of the low, something primary, and that the low, by its distance from them, regulates its own velocity. I have, for my part, a view regarding these areas of rise and fall different from Ekholm's, which was mentioned in the introduction. I would bring those moving areas of falling and rising pressure in close connection with both the currents producing the lows, namely, the northerly cold winds with the areas of rise and the southerly warm winds with the areas of fall, because, first, the extreme temperature changes lie within the areas of rise and fall, and, second, these two currents are the primary cause which gives rise to the low.

Another problem is why there should be a majority of cases of increasing velocity for the areas of fall and decreasing for the areas of rise. I do not know what reason to offer for the first question regarding the falling area, but as to the second I would offer the following explanation. As mentioned above, I am inclined to associate the area of rise with northerly winds; these have their greatest energy of motion near their origin in the extreme northwest, and this energy decreases as they sweep over the plains southward.

Hitherto, in treating the areas of fall and rise, I have considered only the movements of their centers, that is, the points of greatest change in pressure, negative and positive, whether they occupied the central part of the respective areas or were unsymmetrically placed. I have given, as I might say, the kinematics of these points, L, R, and F.

The next question I took up was the following:
On outline blank maps I put for three successive readings

the positions of the centers of lows, the positions of the centers of the areas of fall and rise, and then drew the lines of zero pressure change, which I will shortly call "dead lines." (These lines connect the places where the net change within the last twelve hours is 0.) Having drawn them thus for three successive observations at intervals of twelve hours, I could study how the dead line in front of RA advances with the low, how the contour of its front changes, and how the surface of the area of rise is distributed on both sides of the track of the low.

I have constructed such maps for all of the 170 lows considered, but found that only those could be of some use to me where the paths of the lows were in the middle Mississippi Valley States, so that the extensions of the areas of rise and fall were within the limits of the map.

Upon these charts I tried to compare with each other those lows where the changes of the velocity of the lows for two successive periods of twelve hours were nearly opposite. As examples, consider the eight maps appended as lithographic Charts VIII–XV, in connection with the following remarks:

Group I.
For increasing lows:
    March 11, 1899, a. m., track V, velocity increasing from 234 to 590 miles.
    March 7, 1902, p. m., track III, velocity increasing from 0 to 640 miles.
For decreasing lows:
    March 25, 1901, p. m., track VII, velocity decreasing from 550 to 120 miles.

In the first two cases we find that during the first twelve hours the dead line gained ground on the left side of the track of the low; and in the second twelve hours the advance of the dead line is limited to the right side, while the line on the left side retreated. The center of rise of pressure in the map first considered crosses at an acute angle to the right side of the low; but this is not so in the second case, where it remains on the left.

In the third case (the decreasing low) the front of the dead line is during the first twelve hours farther advanced on the right side of the path of the low, but in the next twelve hours it crosses from the right to the left side of the track, while the center of the rise crosses also from the right to the left side of the low.

Lows with decreasing velocities.

Group II.
    March 6, 1900, a. m., track III, velocity decreasing from 708 to 400 miles.
    January 6, 1899, a. m., track II, velocity decreasing from 885 to 610 miles.
    December 2, 1902, p. m., track I, velocity decreasing from 617 to 470 miles.
    December 3, 1893, p. m., track I, velocity decreasing from 828 to 320 miles.

In the first case the front of the dead line advances in about a north-northeast direction, fairly symmetrically with the track of the low, while the center of rise on the left side approaches the track of the low and follows it pretty closely. In the second case the front advances much farther on the left side than on the right side; the track of the center of rise approaches the track of the low and keeps on the left. In the third case the front is perpendicular to the track of the low, and in the fourth case we find again a greater advance of the dead line on the left side than on the right side.

Low with increasing velocity.

Group III. January 5, 1893, a. m., track III, 370–800 miles.

The front of the dead line keeps ahead on the right side of the track of the low, while the track of the center of rise is on the right side.

In this way I could go on to describe many series of maps

that are similar in their features to those here taken into consideration. If we summarize the deductions above we may say:

I. The lows that move with accelerating velocity are in general characterized by the greater advance of the front of the dead line on the right side of the track of the low than on the left; the track of the center of rise keeps either on the right side or crosses to that side from the left at an acute, a right, and even an obtuse angle.

II. The lows that move with decreasing velocity are characterized by having the front of the dead line perpendicular to the track of the low or with a greater advance on the left side, the track of the center of rise keeping in most cases either on the track of the low or very close to it, usually being on the left side or sometimes even crossing from the right to the left.

In a similar way we could study the dead line in the front of the area of fall and the movements of the centers of the areas of fall as I have done above. If we look through a series of maps of the character described above we find that the centers of the areas of fall generally precede more or less closely the centers of the advancing lows and are no doubt fairly good indicators as to how the lows will move in the next twelve hours, but their relations to the lows on account of their proximity appealed to me less than the characteristics of the areas of rise and their centers.

*   *   *   *   *   *   *

In presenting this short study on areas of rise and fall I can not close without an appeal to those who *see* and *read* better than the writer of this article the daily maps showing the changes of meteorological elements, and to whom, perhaps, part of what has here been said does not appear as something new. The drawing of this kind of charts, which has been done at Washington for a long series of years, and their use for forecasting in the hands of expert forecasters have certainly given rise to many empirical rules about the relation of the "dead line" to the areas of fall and rise, but so far as I know these rules have never been presented for publication to be used by others also and to be interpreted by those who have gained a deeper knowledge of the dynamical nature of cyclones and anticyclones. So with the retirement of a forecaster all of his empirical rules on weather forecasting are lost without becoming the property of practical meteorology. How, then, can one expect an advance in forecasting?

These empirical rules should become the general property of meteorology and should be published, not only for the mutual help of forecasters, but also in the interest of meteorology as a science, even if the forecaster himself can not give a physical explanation of the rules found and used by him.

We draw and write about types of weather; why should we not in a similar way treat pressure, temperature, and other charts? The practical forecaster looks at the weather map with a different eye from the scientific meteorologist, and probably many of the empirical rules of the forecaster can be given a physical explanation by a scientific meteorologist. On the other hand a physical law may receive a practical application in the hands of an expert forecaster.

As an example of this I call attention to the paper of Mr. Bowie, published in the report of the Peoria Convention of Weather Bureau Officials,[6] where he expounds a new method of determining the direction and velocity of the movement of a storm and shows that the direction and the amount of movement is a resultant of two forces, namely:

(1) The component of the eastward drift, (2) the resultant of the pressure "exerted on the storm center" (to use his own words) from all directions. He tries to find some simple,

[6] For second edition see Monthly Weather Review, February, 1906, Vol. XXXIV, p. 61.—Ed.

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geometrical scheme for the expression of these two forces and thus to determine the track of the low.

I know not whether it was known to Mr. Bowie or not, but in reality his text does not say anything more than what is known in meteorology as Kœppen's law of the movements of cyclones, stripped of its physical and dynamic expression, and put in a simplified form applicable to weather forecasting.

That the application of the pressure change charts for weather forecasting is something new in Europe seems to be indicated by the lines of the paper of Professor Ekholm, who either intentionally omits any note on the use of the charts in the United States or else does not know about it. To prove that those empirical rules would be of great interest to many who have read Ekholm's paper just mentioned and have started on this study, I may refer to a note by Mr. Friesenhof (Meteorologische Zeitschrift, May, 1905), who grows quite enthusiastic over the advice of Professor Ekholm.

I therefore wish to finish with the remark that the empirical rules, based on long years of use of these charts in question, should form the subject of many articles in the Monthly Weather Review for the benefit of practical meteorology, which is to-day based *only* on them; their physical interpretation will give us a firmer basis for understanding the weather.

GLAISHER'S FACTORS AND FERREL'S PSYCHROMETRIC FORMULA.

By Prof C. F. Marvin. Dated June 5, 1906.

An article in the Quarterly Journal of the Royal Meteorological Society, Vol. XXXII, No. 173, pages 35–45, January, 1906, by J. R. Sutton, gives a discussion of the differences between dew points and humidities as deduced from readings of the wet-bulb and dry-bulb thermometers by the use of Glaisher's tables of factors of reduction and Ferrel's psychrometric formula and tables.

The writer calls attention to large and striking disagreements in the results derived from these two tables under certain exceptional or extreme conditions, but he afterwards makes this significant statement, page 40:

After all, there is not so much difference as one might expect between the monthly means * * * computed respectively by means of the Greenwich factors * * * and by Ferrel's psychrometric formula.

In illustration of this the mean hourly values for the months of March and November, 1904, respectively the wettest and dryest months, are compared, from which it appears that the mean dew-point for March, by Ferrel, was 0.5° higher than by Glaisher's factors; whereas, for the dry month of November the mean dew-point by Ferrel was 2.6° lower than by Glaisher. In all these observations the wet bulb was subjected to only such ventilation as resulted from the motion of the natural wind. The kind of screen or thermometer shelter employed is not mentioned. In order to make the comparisons the more fair, however, Sutton has applied an empirical correction to the wet-bulb readings, based on the wind velocity observed 40 feet above ground for half an hour before each reading.

In any discussion of the relations and discordances between psychrometric formulæ, it is highly important to keep clearly in mind: 1st. That the psychrometric formulæ commonly employed, even at the best, only approximately express the law of relation between the wet-bulb temperature and the moisture content of the air. 2d. That the numerical coefficients of these formulæ are necessarily computed from certain tests observations which, unfortunately, are always comprised between far too narrow and restricted limits. It is a comparatively easy matter, for example, to make many thousands of simultaneous dew-point and wet-bulb determinations and compute therefrom the coefficients of a psychrometric formula; of these observations, however, relatively a very few will com-